(AD)

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

End-Spring Semester 2016-17

Date of Examination : _____ Session (FN/AN) _____ Duration 3 hrs

Subject No. : EC21006 Subject Name : ELECTROMAGNETIC ENGINEERING

Department/Center/School : E & ECE

Specific charts, graph paper, log book etc., required _____

Special Instructions (if any) : _____

Answer all the questions

The marks for each question is indicated on the right.

Full Marks : 110

1. An air-filled rectangular waveguide is to be constructed for single-mode operation at 15 GHz. Specify the guide dimensions, a and b, such that the design frequency is 10% higher than the cut-off frequency for the TE_{10} mode, while being 10% lower than the cut-off frequency for the next higher-order mode. (8)

2. An air-filled rectangular waveguide of cross section $2.5cm \times 1cm$ is connected to an antenna. For transmission at 11 GHz, find (a) the ratio of the phase velocity to the medium velocity (b) the ratio of the group velocity to the medium velocity (c) intrinsic impedance for the dominant mode.

(4+4+4)

3. Using the following expressions for the TM to z mode :

$$E_x = \frac{1}{j\omega\varepsilon}\frac{\partial^2\psi}{\partial x \partial z},\ E_y = \frac{1}{j\omega\varepsilon}\frac{\partial^2\psi}{\partial y \partial z},\ E_x = \frac{1}{j\omega\varepsilon}\left(\frac{\partial^2}{\partial z^2} + k^2\right)\psi,\ H_x = \frac{\partial\psi}{\partial y},\ H_y = -\frac{\partial\psi}{\partial x},\ H_z = 0$$

derive an expression for the average power transmitted down the guide for the TM_{11} mode for an air-filled rectangular waveguide. (use standard notations for the derivation).

(12)

4. A lossless transmission line is 80 cm long and operates at a frequency of 600 MHz. The line parameters are $L = 0.25\mu H/m$ and $C = 100\,pF/m$. Find the characteristic impedance, the phase constant, the velocity on the line and the input impedance for a load impedance of $Z_L = 100\Omega$.

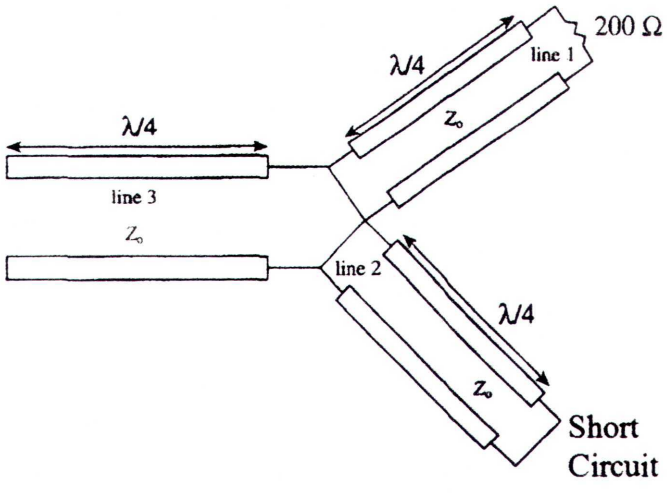
(2+2+2+4)

5. A 50Ω lossless line has a length of 0.4λ. The operating frequency is 300 MHz. A load $Z_L = 40 + j30\Omega$ is connected at $z = 0$, and the Thevenin-equivalent source at $z = -l$ is $12\angle 0^\circ$ V in series with $Z_{Th} = 50 + j0\Omega$. Find

   (a) Reflection coefficient (Γ)
   (b) VSWR
   (c) Input impedance (Z_{in})
   (d) The phasor voltage at $z = -l$
   (e) The phasor voltage at $z = 0$
   (f) The average power delivered to Z_L.

(2+2+4+4+5+3)

6. Consider the three lossless transmission lines in figure given below. If $Z_o = 50\Omega$, calculate:
   (a) Z_{in} looking into line 1
   (b) Z_{in} looking into line 2
   (c) Z_{in} looking into line 3



(3+3+4)

7. A uniform plane wave in air is normally incident on an infinite lossless dielectric material with $\varepsilon = 3\varepsilon_o$ and $\mu = \mu_o$. If the incident wave is $\mathbf{E}_i = 10\cos(\omega t - z)\mathbf{a}_y$ V/m. Find :
   (a) λ and ω of the wave in air
   (b) The incident magnetic field $\mathbf{H}_i$
   (c) Reflection coefficient (Γ) and transmission coefficient (τ)
   (d) The total electric field in both regions and
   (e) The time-average power in both regions.

(2+3+4+5+6)

8. In free space, an electric field is given by $\mathbf{E} = 20\cos(\omega t - 50x)\mathbf{a}_y$ V/m. calculate
   (a) Displacement current density, $\mathbf{J}_d$
   (b) Magnetic field, $\mathbf{H}$
   (c) ω

(3+4+1)

9. Derive the expressions for the electric and magnetic fields excited by a current source $\vec{J}$ in a homogeneous medium. (10)